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Glossary of Terms for Mallee Seeps

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Photo: Chris McDonough

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Important disclaimer

Contents

Acknowledgments 3
Summary 4
- Aquitard 5
- Blanchetown Clay 5
- Discharge zone 5
- Hydrologically balanced landscape 5
- Interception zone 6
- Landscape 6
- Landscape water use 6
- Management intervention 6
- Measuring salinity 7
- Perched watertable 8
- Recharge zone 8
- Regional groundwater 8
- Rehabilitated land 8
- Seep 8
- Seep risk 9
- Soak 9
- Typology of seeps 9

References 11
Appendix 1 – Soil EC datasheet template 12

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Summary

This document is a glossary of terminology for use within the Mallee Seeps project. Its purpose is to provide the project team with consistent language, terminology and measurement units to use where possible. Some of the terms may be revised during the course of the Mallee Seeps project.

Mallee seeps are the expression of subsoil water at or near the ground surface and caused by hydrological imbalances working at a local scale. These are the result of processes occurring at the landscape scale, where the distance between recharge and discharge areas is in the order of hundreds of metres, up to one or two kilometres. Importantly, Mallee seeps are not directly caused by regional groundwater systems, which generally occupy the Mallee at depth, from few metres to many tens of metres (J. A. Hall, 2015). Because of the salt load naturally held in the landscape, the flows of water caused by the hydrological imbalance allow salts to be mobilised, and although seeps generally start as fresh, evaporative concentration may cause seeps to salinise in time. Here we summarise some key terms relevant to our investigation of Mallee Seep processes and their management.

Aquitard

Aquitards are impervious or semi-impervious subsoil layers (may be commonly referred to as impervious clay layers) that are parallel or sub-parallel to the ground surface and create barriers to vertical water drainage. They are typically layers of texture increase (i.e. clayier composition), discrete clay layers or solids like calcrete/limestone. Slowly draining water may persist in situ to form perched watertables, or channelled downhill under gravity over the aquitard and may emerge from the soil as a seep. Blanchetown clay (see “Blanchetown clays”) is sometimes an aquitard in Mallee seeps situations.

Blanchetown Clay

Blanchetown Clay is common throughout the Mallee and was laid down during the Quaternary Period until approximately 700,000 BP as sediment of what is known as Lake Bungunnia. With evidence that its spread covers a significant proportion of the Mallee (particularly in SA), the clay layer represents a significant deep base layer in today’s Mallee landscapes, and may drive hydraulic (groundwater) interactions with the near-surface soil layers and seeps, and may represent a significant store of salts for mobilisation. It is not found everywhere across the Murray Mallee (see J. Hall, Maschmedt, & Billing, 2009; McCord, 1995) because it was not universally laid down or has subsequently been eroded away (J. Hall, 2017, pp. p108-109), and it may be variable in depth from a few centimetres to metres.

Discharge zone

The zone in the landscape downslope of a recharge area where water emerges at the land surface to form a seep. Discharge zones typically grow in area coverage over time, until stabilising in size or shrinking once the land is rehabilitated (see “Rehabilitated land”). Water quality (see “Water quality”) may change in time. Discharge zones include old, natural and persistent wetlands in regional sumps like Lake Tyrrell, Tutchewop or Pink Lakes, which have not developed through altered land use practices.

Hydrologically balanced landscape

The state of the landscape (see “Landscape”) in which the quantity of water delivered through the recharge zone (see “Recharge zone”) is in balance with the water used (i.e. evaporated or transpired by plants). If the quantity of water used is equal to that delivered through the recharge zone, then the landscape is hydrologically balanced. If the quantity is less, then the excessive water passing the plant root zone may cause seeps to be formed. Prior to clearance of agricultural land, landscapes were generally hydrologically balanced because the often deep-rooted perennial native vegetation intercepted and transpired most or all water delivered to recharge zones. Cleared land under broadacre cropping with shallow rooted annual crops typically intercepts less water in recharge zones thus causing a hydrological imbalance and increases the likelihood of seep formation (see “Discharge zone”). A factor influencing hydrological imbalance in recent years may be efforts by growers to increase their water use efficiency through the use of minimum-till and summer weed control, which are possibly contributing to greater soil water recharge.

Interception zone

A strategic zone in which targeted management may prevent excess subsoil water from moving out of the recharge zone (see “Recharge zone”) to interrupt water delivery to a seep or “Discharge zone”. Interception zones normally take the form of plantings of cordons or blocks of native vegetation (trees, bushes and shrubs) or deep-rooted crops with production value like Lucerne positioned in the water flow pathway before reaching the seep.

Landscape

A conceptual unit of land that contains a recharge zone (see “Recharge zone”) (or zones) that is hydraulically connected through a perched watertable (see “Perched watertable”) to a seep or seeps (discharge zone). For this purpose, a landscape is not defined by contributions of water from deeper regional groundwater systems (see “Regional groundwater”), where the main area of recharge may be many kilometres away. A typical landscape can be considered as a hillslope comprising a crest with slope (i.e. a dune) and flat (i.e. swale). Crests and slopes dominate the recharge zones (see “Recharge Zones”). Seeps may express in various parts of the landscape governed by presence of aquitards (see “Aquitard”) or slope shape, and generally in the lower positions (see “Typology of seeps”).

Landscape water use

This refers to the water budget at the landscapes (see “Landscape”) scale, and takes in water/use loss factors including evaporation and transpiration, and groundwater movements, and water supplied (e.g. rainfall). We differentiate this notion from the agronomic concept of water use efficiency (WUE), as per French and Schultz (1984). When a crop uses less water than is supplied to it, and the soil root zone may reach or exceed its water holding capacity, and excess unused water typically passes into the deep(er) soil or stays as a perched watertable (see “Perched watertable”). Low water use therefore can contribute to the growth of the perched water table, water throughflows, and eventually the development and maintenance of seeps. Low water use zones act as recharge zones (see “Recharge zone”). In Mallee farming systems, management practices often focus on maximising the amount of stored soil moisture, such as by summer weed control (reducing water use over summer to build up water stores in the root zone for the winter crop) and minimum tillage practices (reducing evaporation) – potentially reducing overall water use. Where low water use contributes to seep formation, this may be compensated by a range of management interventions (see “Management intervention”).

Management intervention

Changes to management in a seep risk landscape (see ‘Seep risk’) to either halt the growth of seeps or even reverse them so the land is rehabilitated (see “Rehabilitated land”). Interventions may increase water use (see “Landscape water use”) thus reducing recharge (see “Recharge zones”), such as through deeper rooted plantings (e.g. lucerne), or other measures to improve crop root access to soil moisture in the interception zones (see “Interception zones”) (e.g. deep ripping).

Measuring salinity

Soil EC

Two methods are often used to measure the soil electrical conductivity (EC) – a saturated paste extract (EC_e or EC_{se}) or a 1:5 (soil:water) solution ($EC_{1:5}$). The method selected by the Mallee Seeps project team is an $EC_{1:5}$ (soil:water). The protocol for an $EC_{1:5}$ is the following:

Collect soil from designated depths (eg. surface crust, 0-20, 20-40, 40-60 cm). Record the fresh weight of the soil sample+bag. Dry the sample in an oven at 60°C for 3 days and record the dry weight of the soil sample+bag.

Record a soil texture value – either using the ribbon test or by sending samples to a laboratory for soil texture measurement.

Using electronic scales, weigh out 8 g (or 5 g) of soil into a tube for each soil sample.

Add 40 mL (or 20 mL if using 5 g of soil) of water to each tube and secure lid. Record details of the water source used – preferably use MilliQ or reverse osmosis (RO) water. Following the addition of water, place the soil samples on a shaker (preferably an end-over-end shaker) for 1 hour.

Remove the samples from the shaker and allow the soil solution to settle for 30 mins. Record the temperature of the solution.

Following settling, remove lids off the tubes and using a calibrated EC meter to record the raw EC value of the soil solution (avoid the soil layer). Record the value and units for each sample (commonly either µS/cm, mS/m or dS/m and meters often switch between the units). The pH of the same soil:water solution can also be measured using a calibrated pH meter.

The soil:water solution Na+, K+ and Cl- concentrations can be measured using a flame photometer or chloride meter available at The University of Adelaide

Always record the raw $EC_{1:5}$ value obtained from the EC meter (µS/cm or mS/m) and refer to this as the raw unadjusted $EC_{1:5}$ value. The $EC_{1:5}$ value in µS/cm can be converted to dS/m by dividing by 1000 or the $EC_{1:5}$ value in mS/m can be converted to dS/m by dividing by 100 (refer to both these value as an converted $EC_{1:5}$ value). The $EC_{1:5}$ value can also be converted to dS/m using a soil texture correction value (refer to this as a soil texture adjusted $EC_{1:5}$ value) and state the conversion factor used. See the datasheet template in **Appendix 1 – Soil EC datasheet** template.

Table 1: Soil texture correction values

Soil texture	Conversion factor
Sand	15
Sandy loam	12
Loam	10
Clay loam	9
Light-medium clay	8
Heavy clay	6

Obtained from https://www.agric.wa.gov.au/soil-salinity/measuring-soil-salinity accessed 15 Jan 2020.

Groundwater EC and pH

Collect a fresh sample of groundwater from the piezometer. Record whether the piezometer has been pumped of water and length of time. If groundwater contains soil particles allow the groundwater to settle in a container with a sealed lid before EC/pH measurements.

Use a calibrated EC meter to record the EC value of the groundwater sample and note the units for each sample (commonly either µS/cm, mS/m or dS/m and meters often switch between the units).

Use a calibrated pH meter to record the pH value of the groundwater sample.

A complete soil test (including soil texture) using an Australasian Soil and Plant Analysis Council (ASPAC) approved soil testing facility is recommended for at least one soil core (and associated depths) collected at the seep locations.

Perched watertable

When excess water caused by low water use (see "Landscape water use") in the recharge zone (see "Recharge zone") preferentially moves through permeable soils beyond the plant root zone and reaches an aquitard layer. The excess water forms perched watertables (i.e. locally saturated zones in the soil profile) when it reaches deep layers of low permeability clay and its downward movement is impeded.

Recharge zone

The landscape zone where the majority of water contributing to seep development enters the landscape. The relative water recharge contribution of the zone is governed by the water use (see "Landscape water use") in the zone, and typically the water use reduces with the shift from deep-rooted perennial native vegetation to shallow rooted annual crop vegetation with land clearance.

Regional groundwater

A groundwater system that is characteristically deep in the landscape, below a perched watertable (see "Perched watertable"), is slow moving, and where the recharge area and discharge areas may be separated by large distances, i.e. beyond the distance defining a landscape (see "Landscape").

Rehabilitated land

Seep land in the discharge zone (see "Discharge zone") that has had prior productivity restored after successful targeted management intervention, e.g. placement of an interception zone (see "Interception zone"); the landscape is now likely to be a hydrologically balanced landscape (see "Hydrologically balanced landscape").

Seep

See "Discharge zone"

Seep risk

The rate or likelihood that a landscape (see “Landscape”) will develop seeps. A landscape underpinned by a perched watertable, and that is at or near to its capacity to hold water, can be considered at high seep risk. Further additions of water to the landscape may cause emergence of seeps. The scale of landscapes (see “Typology of seeps”) will likely influence both the tendency of a landscape to express seeps, but also the rate at which the landscape responds to management interventions. ‘Broad’ landscapes, because of their greater physical capacity to hold water, may ‘prime’ slower than ‘tight’ landscapes. Conversely, ‘broad’ landscapes are likely to respond more slowly in response to management interventions.

Soak

See “Discharge zone”

Typology of seeps

This is a working categorisation of Mallee seeps that may be subject to revision. The seep typology may be used to select appropriate management options. In order to ensure that seeps can be described without detailed investigation, we initially focus on three ***readily observable*** factors: scale, expression position and water quality.

Scale refers to the lateral distance or extent between the recharge and discharge zones in the landscape. The seep system can be ‘tight’, where the recharge and discharge zones are <100-200 m apart, or ‘broad’, where the system covers areas of several hundred metres, to possibly 1-2 km. The concept of scale may be further developed – it is possible that concepts of “complexity”, “interconnectedness” and “jumbledness” may prove more meaningful than scale alone. In a tight system, the source of water may be more obvious than in a broad system. The scale is likely to have an influence on the speed of water movement through the system, which may guide land use and other management strategies.

Expression position refers to the part of the landscape in which the discharge area appears. This is likely a function of the nature and location of aquitards (see “Aquitard) leading to the seep. Three possible landscape sites of expression are possible, namely: perched upper seep, upper break-of-slope seep and lower-slope seep are illustrated in the following figure.

Emergent seeps are usually initially freshwater (see “Water Quality”) but in time may become saline and/or become acid sulfate soils (see “Water quality”).

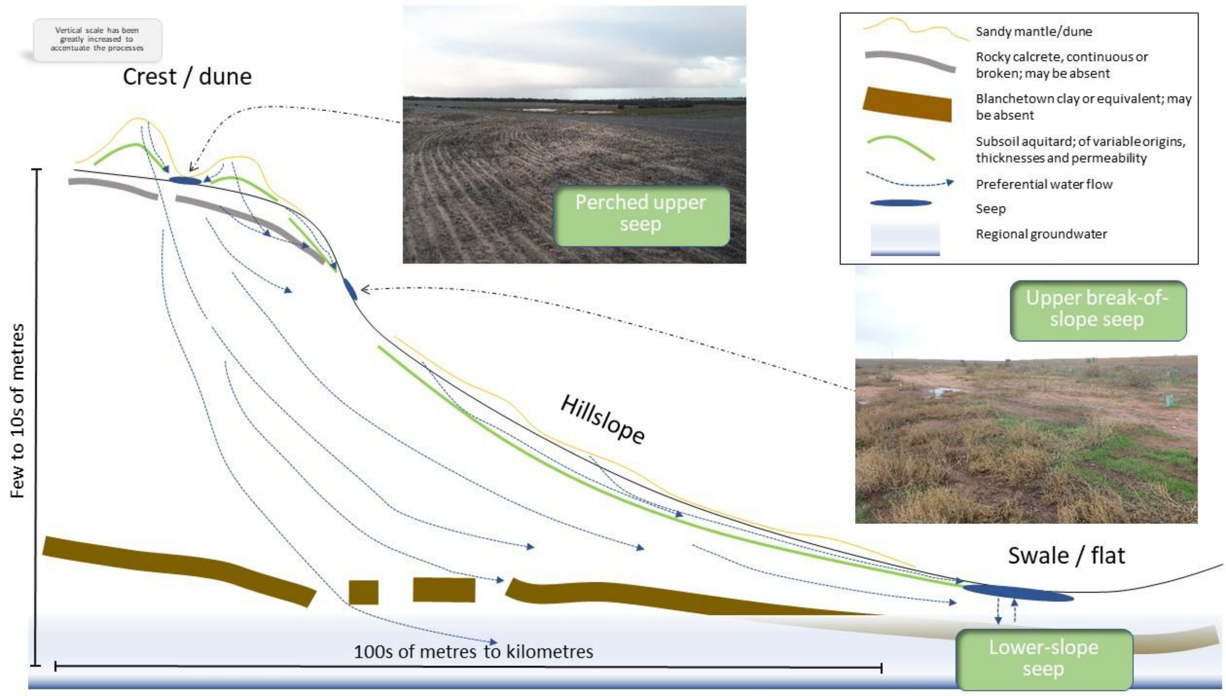

Figure 1. Schematic diagram of the elements of Mallee seeps; not all elements may occur in a given landscape. The vertical scale has been accentuated to highlight vertical elements

Water quality is a readily observable characteristic of seeps. Seeps are typically fresh or slightly saline when they first appear, but there may be an eventual transition from fresh to saline as the salts supplied to the soil concentrate due to evaporation/transpiration (see "Measuring salinity"). Soil salinity may progressively increase to concentrations that may affect or prohibit plant growth according to the plant's salinity tolerance. Accordingly, salinity may be a function of the age of a seep.

An additional subset of saline seeps are sulfidic (Fanning & Fanning, 1989). These seep soils require very different management compared to fresh or saline seeps as the soils may become very acidic when they dry. Acid sulfate soils are a category of saline soils containing sulforous materials. When wet as sulfides (wet, black, "rotten egg" smelling), are not acidic. Oxidation of sulfides through soil drying causes sulfuric acid to be created with pH <4, which is strong enough to break down soil minerals to release noxious or toxic materials into the environment. When drying, the land surface may appear red or red-brown stained, and once fully dry, the black material below the surface becomes generally yellow due to formation of mineral Jarosite. While ASS have been locally observed in Mallee seeps, the prevalence needs to be better understood.

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Appendix 1 – Soil EC datasheet template

Sample #	Description of soil sample location	Site	GPS location (if available)	Year	Date Soil Sampled	Soil Depth (cm)	Soil Texture	Raw unadjusted $EC_{1:5}$ measurement		Converted $EC_{1:5}$ value (dS/m)	Soil Texture Conversion Number	Soil Texture Adjusted $EC_{1:5}$ value (dS/m)
								Raw $EC_{1:5}$ value	Units of Raw $EC_{1:5}$ value			

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